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RISONATORI CERAMICI PIEZOELETTRICI

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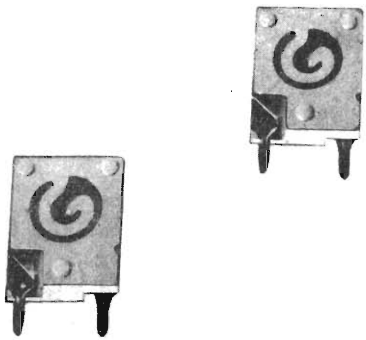
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RISONATORI CERAMICI PIEZOELETTRICI

* Dati tecnici aggiornati

** Tipi nuovi

PIEZOELECTRIC CERAMIC RESONATORS
for a.m. radio receivers



RZ 27497-2

Resonant frequency	452, 455, 460, 468 and 470 kHz
Quality factor	> 800
Ambient temperature range	-25 to +85 °C

GENERAL

The piezoelectric effect of lead-zirconate-titanate ceramic material makes it possible to obtain a component, the ceramic resonator, of which the physical behaviour is comparable with that of quartz crystals.
With the ceramic resonators described in these sheets frequency selection elements can be built with electrical characteristics far better than could be achieved with conventional LC-resonant circuits. Compared with such conventional circuits the resonators offer several other advantages:

- miniature size
- low price
- high quality factor
- high long-term stability
- shielding is unnecessary since there are no magnetic fields
- aligning is also unnecessary.

DESCRIPTION

A disc of piezoelectric ceramic material, provided with gold electrodes, is put in a rectangular white plastic casing, and resiliently clamped between two gold-plated contact plates. This gold-to-gold construction assures good electrical contacts under the severest environmental conditions. The contact plates are insulated by transparent plastic plates.
There are two versions, both pluggable, one for printed-wiring boards with holes of 1.3 mm diameter and 1.5 mm thickness (see Fig.1) and one for printed-wiring boards with 0.8 mm holes and 1.0 mm thickness (see Fig.2).

Dimensions in mm

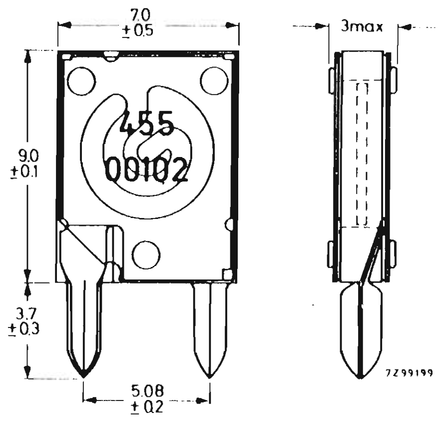


Fig.1

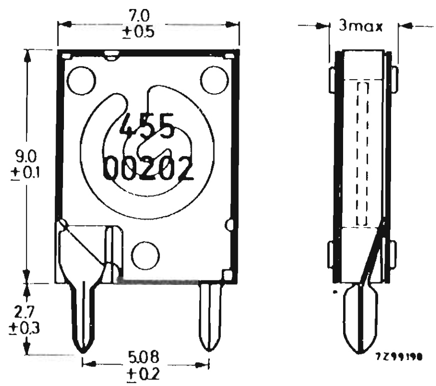


Fig.2

Marking

The resonators are marked with the resonant frequency and the last five digits of the catalogue number. The marking is made at the inside of the transparent insulating plates so that it cannot be rubbed out.

TECHNICAL PERFORMANCE (see also Fig.5)

Resonant frequency (f_r)	452, 455, 460, 468 or 470 kHz
Tolerance on the resonant frequency (incl. ageing over a period of 10 years)	± 1 kHz
Quality factor ($Q = \frac{2\pi f_r L_1}{R_1}$)	> 800 (typical value: 1000)
Inductance (L_1)	8.5 mH ± 10%
Capacitance ($C = C_0 + C_1$), measured at 1 kHz	see table below
Maximum permissible a.c. voltage at resonant frequency	100 mV_{rms}
Maximum permissible d.c. voltage	30 V
Ambient temperature range	-25 to +85 °C
Temperature coefficient of the resonant frequency	< 85 ppm/deg C
Solderability	250 °C, max. soldering time 5 s

f_r (kHz)	capacitance at 1 kHz (pF)	catalogue number	
		version for printed-wiring boards with holes of 1.3 mm (see Fig.1)	version for printed-wiring boards with holes of 0.8 mm (see Fig.2)
452	190	2422 540 00101	2422 540 00201
455	180	102	202
460	180	103	203
468	180	104	204
470	180	105	205

PHYSICAL BEHAVIOUR

The combination of piezoelectric and typical mechanical properties makes it possible to bring the resonator in vibration by applying an alternating voltage to the electrodes.
At certain fix frequencies dependent on the dimensions of the resonator different modes of vibration are possible.
In a small frequency band at about 450 kHz (fundamental resonant frequency) our resonators prefer to vibrate radially (see Fig.3), in other words the diameter of the disc increases and decreases alternatingly.

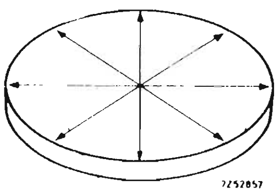


Fig.3

If the modulus of the impedance of a piezoelectric resonator, measured in the vicinity of the fundamental resonant frequency, is plotted against the frequency, the result is the curve shown in Fig.4. The frequency where the impedance passes a minimum and a maximum are termed resonant frequency (f_r) and anti-resonant frequency (f_a) respectively.

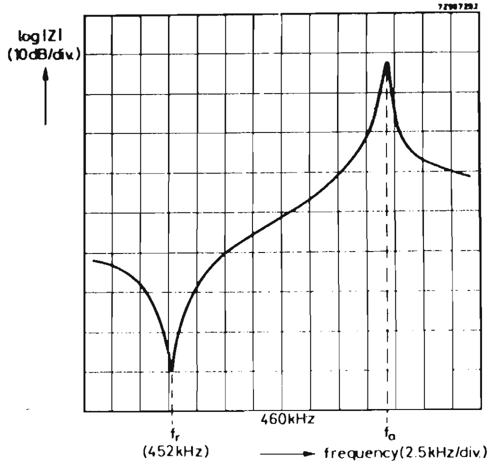


Fig.4

Closer investigation of this particular resonator shows that the impedance at the resonant and the anti-resonant frequency is purely ohmic.
The impedance curve shows a very similar behaviour to quartz crystals but with the important differences: a lower quality factor and a greater separation of the resonant and anti-resonant frequency for the resonators.
The latter property makes ceramic resonators very suitable for use in radio receivers, where filters are required with a rather large bandwidth which is impossible to realize with quartz crystals.
It is possible to define an equivalent circuit of the resonator; the simplest form is shown in Fig.5, which is applicable to a wide frequency range.

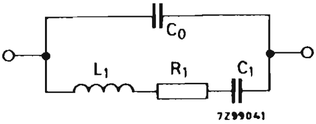


Fig.5

Measuring methods

Users of resonators will be interested in the values of the various elements of the equivalent circuit (see Fig.5). Since the four equivalent constituent elements of the piezoelectric filter, viz. coil L_1, resistor R_1 and capacitors C_1 and C_o do not exist as such, their values will have to be evaluated from four different indirect measurements. These measurements can be carried out in different ways.
One method is to measure the following quantities:
- the resonant frequency f_r
- the anti-resonant frequency f_a
- the resistance R_1 at the resonant frequency
- the capacitance C at a frequency far below f_r

The resonant frequency f_r, as well as resistance R_1 at resonance can be measured directly with the circuit of Fig.6 if the external series resistance $R_a \gg$ resonator impedance at f_r. The impedance at resonance is represented by resistor R_1 in parallel with capacitor C_o (Fig.5) whose impedance is so high that it has negligible effect. At the frequency f_r the voltmeter gives a minimum reading V_2, so that the value of R_1 can be calculated from

$$R_1 = \frac{V2}{V_1 - V_2} R_a$$

The anti-resonant frequency f_a can be measured with the circuit of Fig.7, under the condition that $R_b \ll$ resonator impedance at f_a.

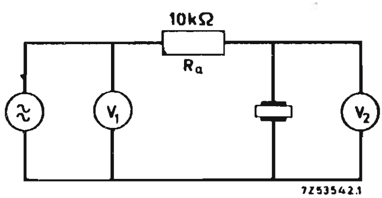


Fig.6. Circuit for measuring f_r.

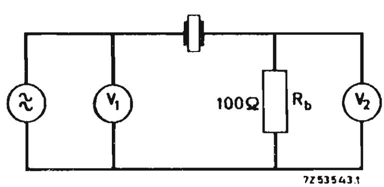


Fig.7. Circuit for measuring f_a.

When measuring the capacitance of the resonator at a frequency far below the resonant frequency, say 1 kHz, one finds a value C which is the sum of C_o and C_1.

Once the above measurements of f_r, f_a, R_1 and C have been carried out, each of the four elements representing the resonator can be easily calculated.

$$f_r = \frac{1}{2\pi\sqrt{L_1 C_1}} \quad (1) \qquad f_a = \frac{1}{2\pi\sqrt{L_1 \dfrac{C_1 C_o}{C_1 + C_o}}} \quad (2) \qquad C = C_1 + C_o \quad (3)$$

With equation (1) and (2) we obtain:

$$\frac{C_o}{C_1} = \frac{f_r^2}{f_a^2 - f_r^2}$$

so that with equation (3):

$$C_1 = \frac{C}{1 + (C_o/C_1)} = C\,\frac{f_a^2 - f_r^2}{f_a^2} \quad \text{and} \quad C_o = C - C_1$$

With equation (1) L_1 can now be calculated:

$$L_1 = \frac{1}{4\pi^2 f_r^2 C_1}$$

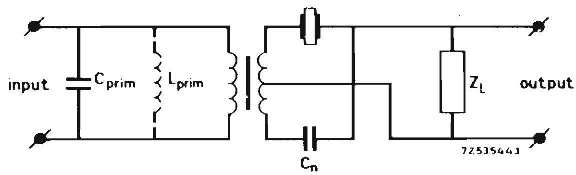
Furthermore the quality factor Q_1 follows from:

$$Q_1 = \frac{1}{2\pi f_r C_1 R_1}$$

APPLICATION INFORMATION

An interesting application of the resonator is the combination with an electrical resonant circuit as shown in Fig.8 (capacitance C_n serves to neutralize parallel capacitance C_o of the resonator). The result is a second order filter comprising a parallel circuit (LC circuit) and a series circuit (resonator).

a.



b.

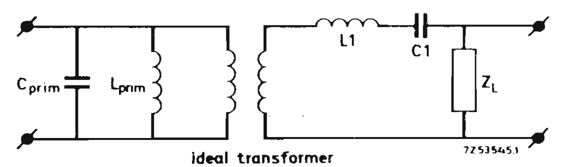


Fig.8. (a) Ceramic resonator combined with an electrical resonant circuit;
(b) equivalent circuit.

It is also possible to obtain a third order filter by means of the combination of two LC circuits with one resonator (see Fig.9).

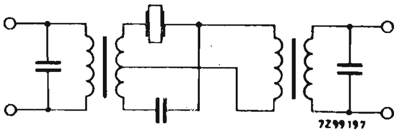


Fig.9

If a filter is designed with a performance comparable for what the passband concerned to this third order filter, the damping is much higher if instead of a resonator a conventional tuned LC circuit with a relative low quality factor is used.
Due to the application of the ceramic resonator with a high quality factor the damping in the passband is of such order that it allows the whole selectivity to be concentrated in one block preceding the i.f. amplifier. This so-called lumped selectivity, being a feature in manufacturing conventional radio receivers, is a must when integrated circuits are used in the i.f. part.

In the following paragraphs some filters are described. Additional information can be obtained on request.

Second order hybrid bandpass filter

This filter can serve as complete selectivity unit in simple radio receivers or replace double tuned LC sections in more complicated receivers. The capacitor C_n is a neutralising capacitor which compensates the asymmetry of the bandpass curve caused by the parallel resonance of the resonator.

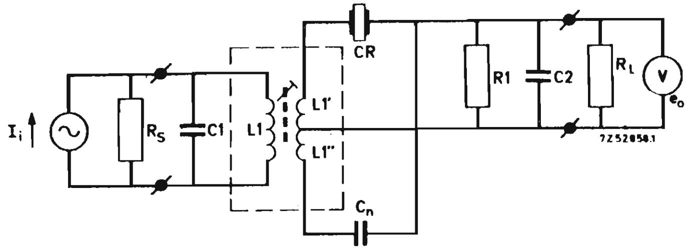


Fig.10. Circuit diagram of a second order hybrid bandpass filter

Parts list:

R_S = output impedance of the preceding mixer/oscillator transistor BF195; typical value 250 kΩ at 1 mA (source impedance).

R_ℓ = input impedance of the following i.f. transistor BF194; typical value 3 kΩ at 1 mA (load impedance).

R_1 = 470 Ω

C_1 = 3000 pF
C_2 = 3300 pF
C_n = 270 pF

L_1 = 40 μH
V_{L1}'/V_{L1} = 0.115
V_{L1}''/V_{L1} = 0.077
Coupling factor k = approx. 1
Unloaded quality factor Q_o of tuned circuit = 130; Q (resonator) = approx. 1000

CR = ceramic resonator 2422 540 00...

Characteristics:

B_{3dB} = 4.5 kHz
Selectivity (± 9 kHz) = 26 dB
Midband frequency (f_m) = 452 kHz
Transfer impedance (Z_T) = 700 Ω
Ripple: 0.5 dB (nominal).

Frequency characteristics (midband frequency f_m = 452 kHz)

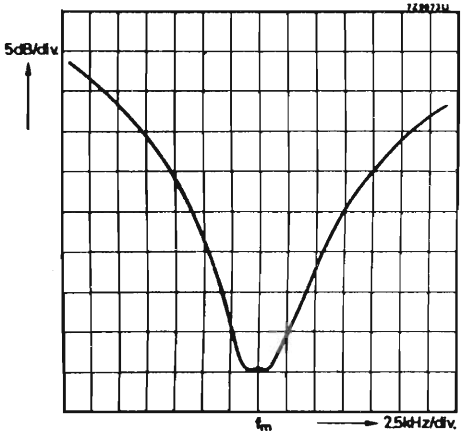


Fig.11

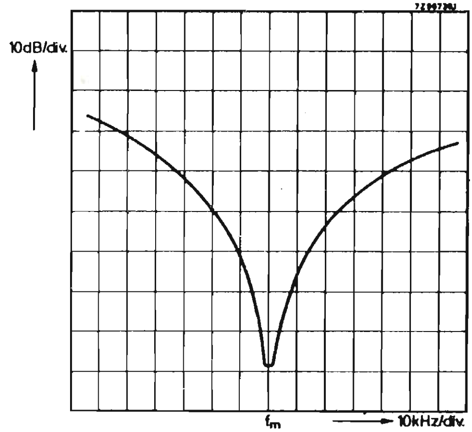


Fig.12

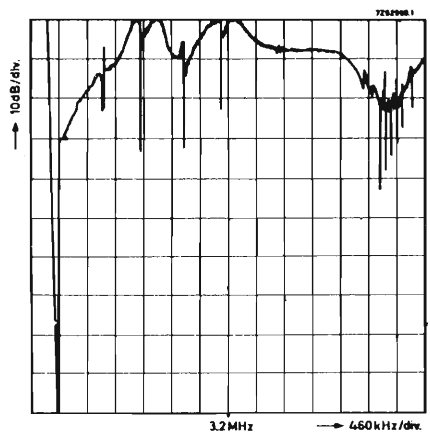


Fig.13

Third order hybrid bandpass filter

A third order filter is designed for more sophisticated radio receivers. The selectivity of this filter is about 10 dB better than that of the second order filter. Resistor R_1 provides the additional damping required for a symmetric bandpass curve.

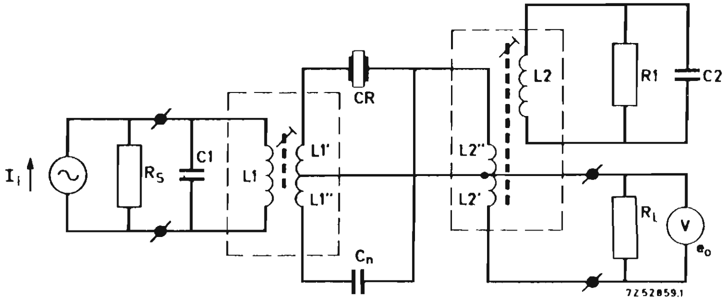


Fig.14.Circuit diagram of a third order hybrid bandpass filter

Parts list:

R_S = output impedance of the preceding mixer/oscillator transistor BF195; typical value 250 kΩ at 1 mA (source impedance)

R_ℓ = input impedance of the following i.f. transistor BF194; typical value 3 kΩ at 1 mA (load impedance).

R_1 = 82 kΩ

C_1 = 3000 pF
C_2 = 3000 pF
C_n = 270 pF

$L_1 = L_2$ = 40 μH
$V_{L1}'/V_{L1} = V_{L2}'/V_{L2} = 0.115$
$V_{L1}''/V_{L1} = V_{L2}''/V_{L2} = 0.077$

Unloaded quality factor Q_o of tuned circuits (excluding R_1) = 130; Q (resonator) = approx. 1000
CR = ceramic resonator 2422 540 00...

Characteristics:

B_{3dB} = 4.5 kHz
Selectivity (± 9 kHz) = 36 dB
Transfer impedance (Z_T) = 500 Ω

Frequency characteristics (midband frequency f_m = 452 kHz)

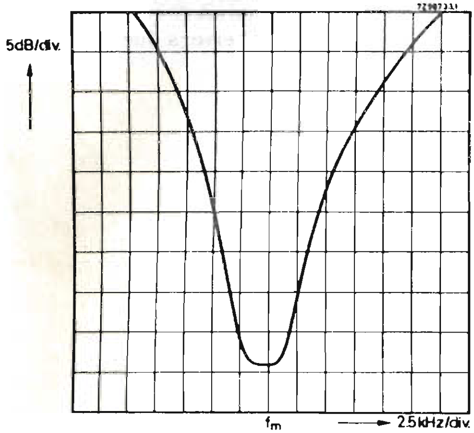


Fig.15

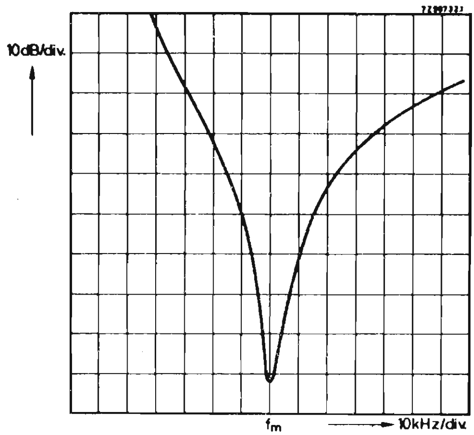


Fig.16

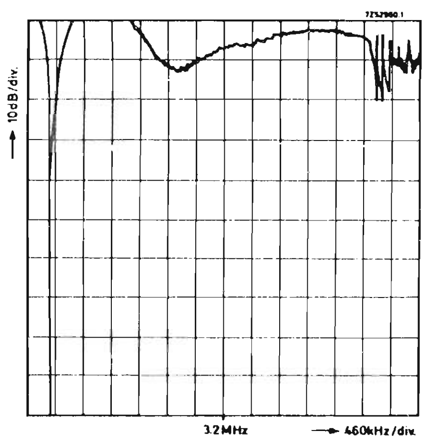


Fig.17

Aerial filter

A ceramic resonator in the aerial circuit can suppress the i.f. frequency about 32 dB. The resonator decouples the base of the mixer-transistor at the i.f. frequency. This application is not recommended for short-wave receivers due to the thickness resonances of the resonator.

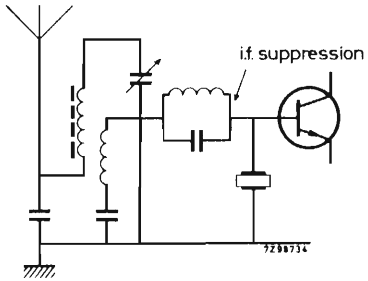


Fig.18

Emitter bypassing

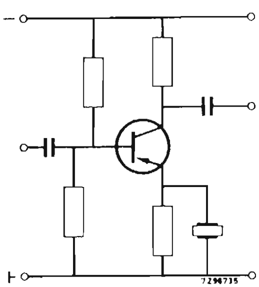


Fig.19

At the resonant frequency and in the neighbourhood of this frequency the ceramic resonator diminishes the feedback effect of the emitter resistor

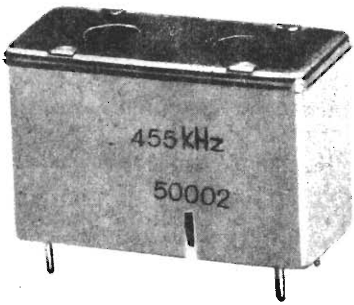
Loaded quality of the resonator = $Q_L = \dfrac{Q}{1 + \dfrac{y_e}{y_{fe}}}$

$$B_{3dB} = \frac{f_r}{Q}\left(1 + \frac{y_e}{y_{fe}}\right)$$

in which:

f_r = resonant frequency of the resonator
Q = quality factor of the resonator
y_e = admittance of the emitter circuit (resonator parallel to resistor) at resonant frequency
y_{fe} = forward transfer admittance of the transistor.

HYBRID FILTERS WITH CERAMIC RESONATORS



RZ 27497-4

INTRODUCTION

These high-quality hybrid intermediate-frequency filters have been developed for use in radio sets, especially in conjunction with integrated circuits, and in telecommunication receivers.
Each comprises one input and one output LC resonant circuit, and one or several piezoelectric ceramic resonators, built into a metal encapsulation.
Important features of these filters, when compared with conventional ones, are:
- high i.f. selectivity (due to the ten times better Q value of the ceramic resonators)
- small size
- i.f. alignment of the receiver unnecessary, since they are adjusted in our factory.

TECHNICAL DATA

General

The electrical data can be found in the data sheets of the filters concerned, except the data for the permissible temperature range and for the temperature coefficient of the midband frequency which are given below.

For the midband frequency, 3 dB pass-bandwidth and selectivity the following definitions apply (see also Fig. 1).
The midband frequency (f_m) is the geometrical mean of the frequencies at which the relative attenuation reaches a value of 3 dB.
The 3 dB pass-bandwidth (B_{3dB}) is the separation of frequencies between which the attenuation is equal to or less than 3 dB.
The selectivity (S_9) is the attenuation at a frequency that is 9 kHz higher or lower than f_m.

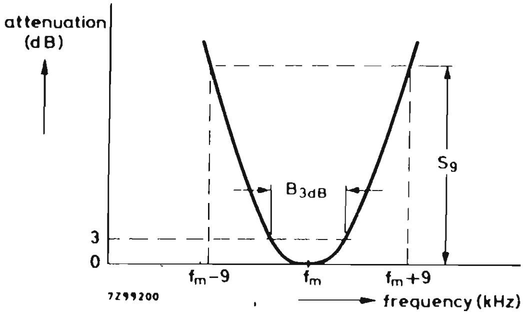


Fig. 1

Unless otherwise specified all electrical data apply to an ambient temperature of 25 ± 1 °C, an air pressure of 930-1060 mbar and a relative humidity of less than 75%.

Operating temperature range — −25 to +75 °C

Temperature coefficient of the midband frequency — < 85 ppm/deg C

The frequency characteristic and the 3 dB pass-bandwidth will remain fairly constant within the operating temperature range. Hence a receiver with a good temperature stability may be obtained by using an oscillator with optimum temperature drift.

Construction

The various components of the filter are fitted on a small printed-wiring board. The assembly is enclosed by a metal encapsulation, which is provided with pins for plugging the filter into a printed-wiring board with a thickness of 1.6 mm.

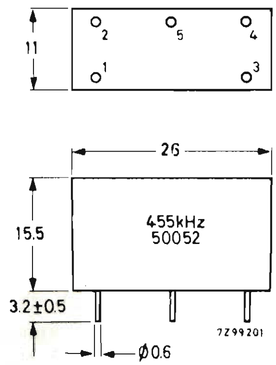


Fig.2. Dimensions in mm

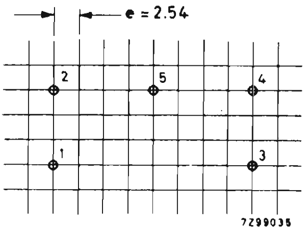


Fig.3. Hole pattern of the printed-wiring board (viewed on circuit side)

Weight approx. 5 g

Marking

The filters are marked with the midband frequency and the last five digits of the catalogue number.

THIRD ORDER HYBRID FILTERS

GENERAL

These filters have a high transfer impedance and so a rather low transducer loss, and have to be loaded with high impedances. They are highly suited to be used in conjunction with TAD 100 integrated circuits (see Fig. 5).

ELECTRICAL DATA

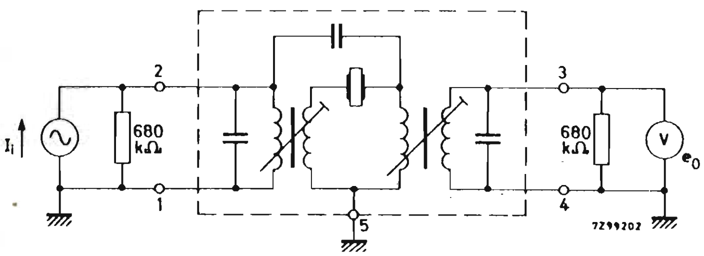


Fig. 1. Circuit diagram of the filters with measuring circuit.
To obtain nominal performance connect pins 1, 4 and 5 to earth.
If this is not possible pins 1 and 4 may remain disconnected from earth.

Midband frequency (f_m)	452, 455, 460, 468 and 470 kHz
Bandwidth at an attenuation of 3 dB (B_{3dB})	> 4 kHz (typical value: 5 kHz)
Attenuation at 9 kHz de-tuning with respect to f_m (S_9)	33 dB (typical value)
Stop band rejection	
up to 5 MHz	> 90 dB
between 5 and 30 MHz	> 70 dB

The filters are designed on the following impedance levels:

Output impedance of preceding stage (source impedance R_s)	680 kΩ (typical value)
Input impedance of succeeding stage (load impedance R_ℓ)	680 kΩ (typical value)

Transfer impedance at midband frequency $|Z_T| = \left|\frac{e_{o_m}}{i_{i_m}}\right|$ = 63 kΩ (typical value)

e_{o_m} = output voltage
i_{i_m} = input current
} at midband frequency

The insertion loss and transducer loss are exactly determined by these properties and can be calculated as follows:

Insertion loss $= 20 \log \frac{R_s R_\ell}{Z_T (R_s + R_\ell)} = 14.5$ dB

Transducer loss $= 10 \log \frac{R_s R_\ell}{4 Z_T^2} = 14.5$ dB

Typical attenuation curves.

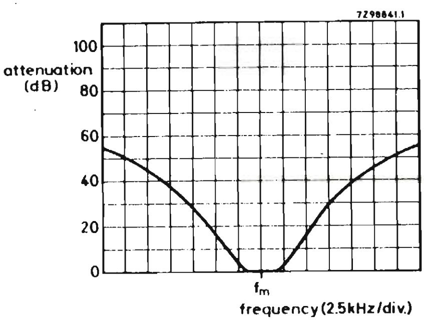


Fig.2

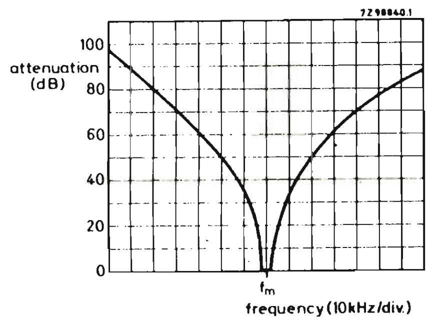


Fig.3

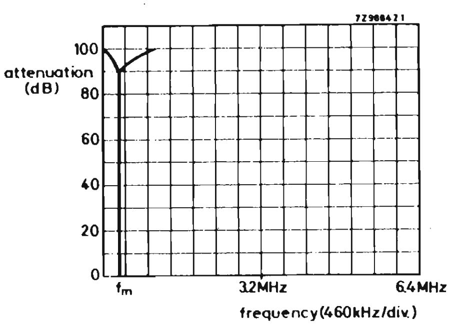


Fig.4

AVAILABLE VERSIONS

midband frequency (f_m) ± 1 kHz	catalogue number
452 kHz	2422 540 50001
455 kHz	50002
460 kHz	50003
468 kHz	50004
470 kHz	50005

APPLICATION INFORMATION

Fig.5 gives the diagram of a radio receiver in which the filter 2422 540 50003 is used in conjunction with an integrated circuit TAD100.
The TAD100 is a radio circuit for a.m. portables operating from either a 6 V or 9 V battery.
It combines in one envelope all the active devices needed for the oscillator, mixer, i.f. amplifier, detector, a.g.c. and a.f. pre-amplifier and driver stages. The only additional active devices required to form a complete receiver are a pair of complementary output transistors. Using discrete transistors for the audio output stage provides a variety of output powers with only minor changes to the external circuitry. I.F. selectivity is obtained by means of the block filter. The oscillator and aerial circuit are of conventional design.
For detailed information the Application Information Bulletin 138 should be consulted.

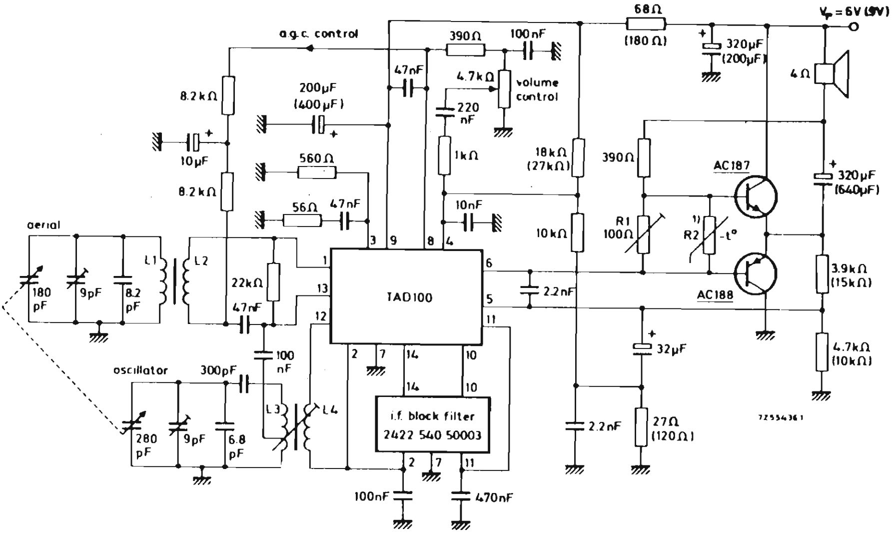


Fig.5

THIRD ORDER HYBRID FILTERS

GENERAL

These filters have been developed for use in conjunction with the silicon transistors BF194 and BF195.
They are rather insensitive for variations of the source and load impedances.

ELECTRICAL DATA

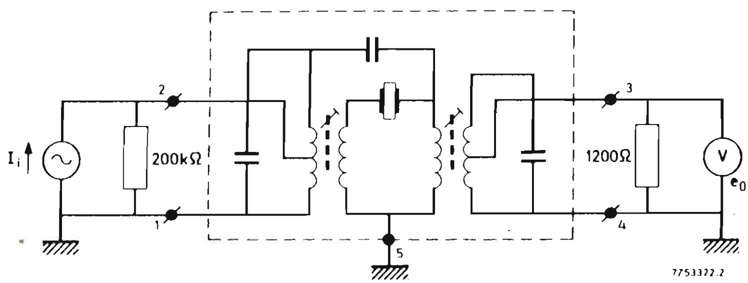


Fig. 1. Circuit diagram of the filters with measuring circuit.
To obtain nominal performance connect pins 1, 4 and 5 to earth.
If this is not possible pins 1 and 4 may remain disconnected from earth.

Midband frequency (f_m)	452, 455, 460, 468 and 470 kHz
Bandwidth at an attenuation of 3 dB (B_{3dB})	> 4 kHz (typical value: 4.7 kHz)
Attenuation at 9 kHz de-tuning with respect to f_m (S9)	35 dB (typical value)
Stop band rejection	
up to 5 MHz	> 90 dB
between 5 and 30 MHz	> 30 dB

The filters are designed on the following impedance levels:

Output impedance of preceding stage (source impedance R_s)	200 kΩ (typical value)
Input impedance of succeeding stage (load impedance R_ℓ)	1200 Ω (typical value)

Transfer impedance at midband frequency $|Z_T| = \left|\frac{e_{om}}{i_{im}}\right| = 600\ \Omega$ (typical value)

e_{om} = output voltage } at midband frequency
i_{im} = input current }

The insertion loss and transducer loss are exactly determined by these properties and can be calculated as follows:

Insertion loss $= 20 \log \frac{R_S R_\ell}{Z_T (R_S + R_\ell)} = 6$ dB

Transducer loss $= 10 \log \frac{R_S R_\ell}{4 Z_T^2} = 22$ dB

Typical attenuation curves.

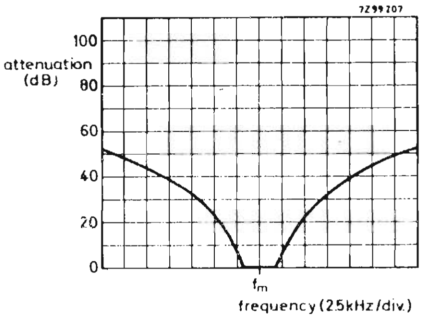


Fig.2

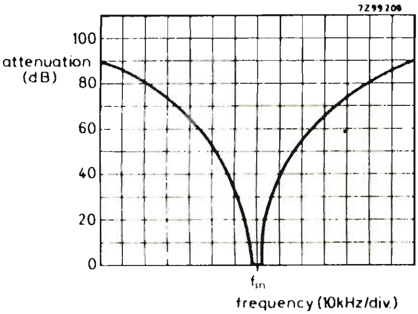


Fig.3

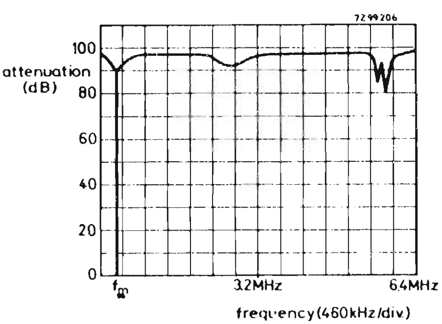


Fig.4

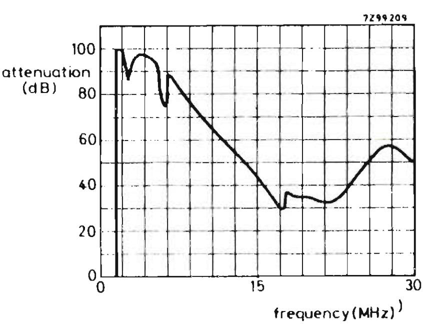


Fig.5

AVAILABLE VERSIONS

midband frequency (f_m) ± 1 kHz	catalogue number
452 kHz	2422 540 50031
455 kHz	50032
460 kHz	50033
468 kHz	50034
470 kHz	50035

THIRD ORDER HYBRID FILTERS

GENERAL

These filters have the same performance as those of the 2422 540 5003. series, but the stop band rejection between 5 and 30 MHz is higher, so they are highly suited to be used in short wave radio receivers.
The filters can be used in conjunction with TAA840 integrated circuits (see Fig. 6).

ELECTRICAL DATA

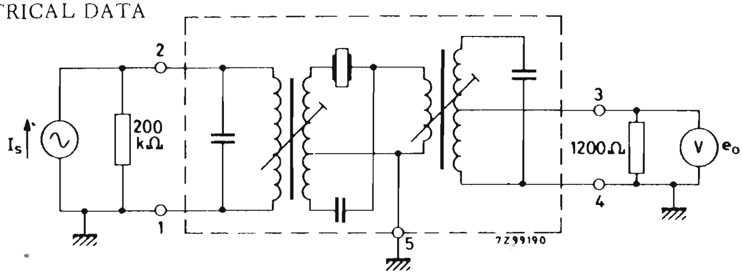


Fig. 1. Circuit diagram of the filters with measuring circuit.
To obtain nominal performance connect pins 1, 4 and 5 to earth.
If this is not possible pins 1 and 4 may remain disconnected from earth.

Midband frequency (f_m)	452, 455, 460, 468 and 470 kHz
Bandwidth at an attenuation of 3 dB (B_{3dB})	> 4 kHz (typical value: 5 kHz)
Attenuation at 9 kHz de-tuning with respect to f_m (S_9)	33 dB (typical value)
Stop band rejection	
up to 5 MHz	> 90 dB
between 5 and 30 MHz	> 70 dB

The filter is designed on the following impedance levels:

Output impedance of preceding stage (source impedance R_s)	200 kΩ (typical value)
Input impedance of succeeding stage (load impedance R_ℓ)	1200 Ω (typical value)

Transfer impedance at midband frequency $|Z_T| = \left|\frac{e_{om}}{i_{im}}\right| = 600\ \Omega$ (typical value)

e_{om} = output voltage
i_{im} = input current
} at midband frequency

The insertion loss and transducer loss are exactly determined by these properties and can be calculated as follows:

$$\text{Insertion loss} = 20 \log \frac{R_S R_\ell}{Z_T (R_S + R_\ell)} = 6\ \text{dB}$$

$$\text{Transducer loss} = 10 \log \frac{R_S R_\ell}{4 Z_T^2} = 22\ \text{dB}$$

Typical attenuation curves.

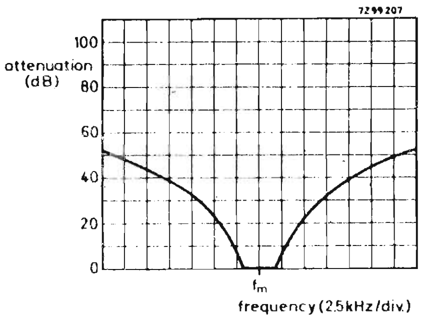


Fig.2

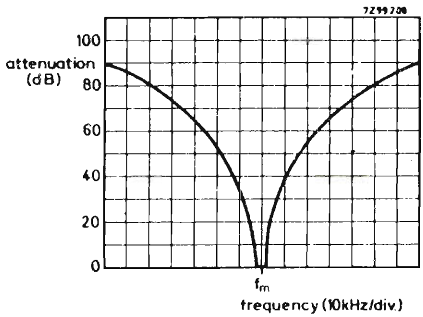


Fig.3

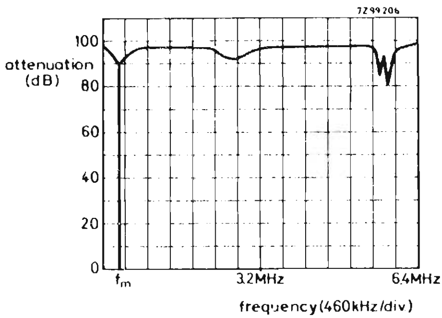


Fig.4

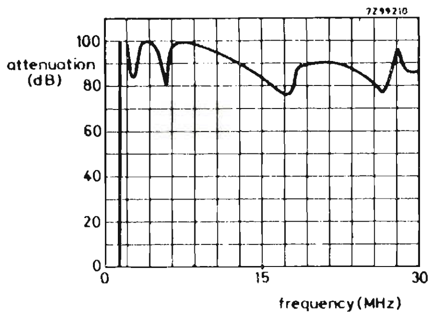


Fig.5

AVAILABLE VERSIONS

midband frequency (fm) ± 1 kHz	catalogue number
452 kHz	2422 540 50051
455 kHz	50052
460 kHz	50053
468 kHz	50054
470 kHz	50055

APPLICATION INFORMATION

Fig.6 gives the diagram of a m.w./l.w. portable radio receiver in which a filter of the 2422 540 5005. series is used in conjunction with an integrated circuit TAA840. The TAA840 is an integrated circuit designed to replace all active elements in an a.m. receiver except the a.f. output stages. It combines an r.f. wideband pre-amplifier, a self-oscillating mixer, an i.f. amplifier, a detector and an a.f. pre-amplifier and driver stage. The r.f. pre-amplifier and the first i.f. stage are reverse-controlled by an a.g.c. amplifier.
Conventional coils are used for the oscillator and ferrite rod aerial.
The TAA840 can be operated from either a 6 V or a 9 V supply voltage.
For detailed information the Application Report EBA 6909 should be consulted.

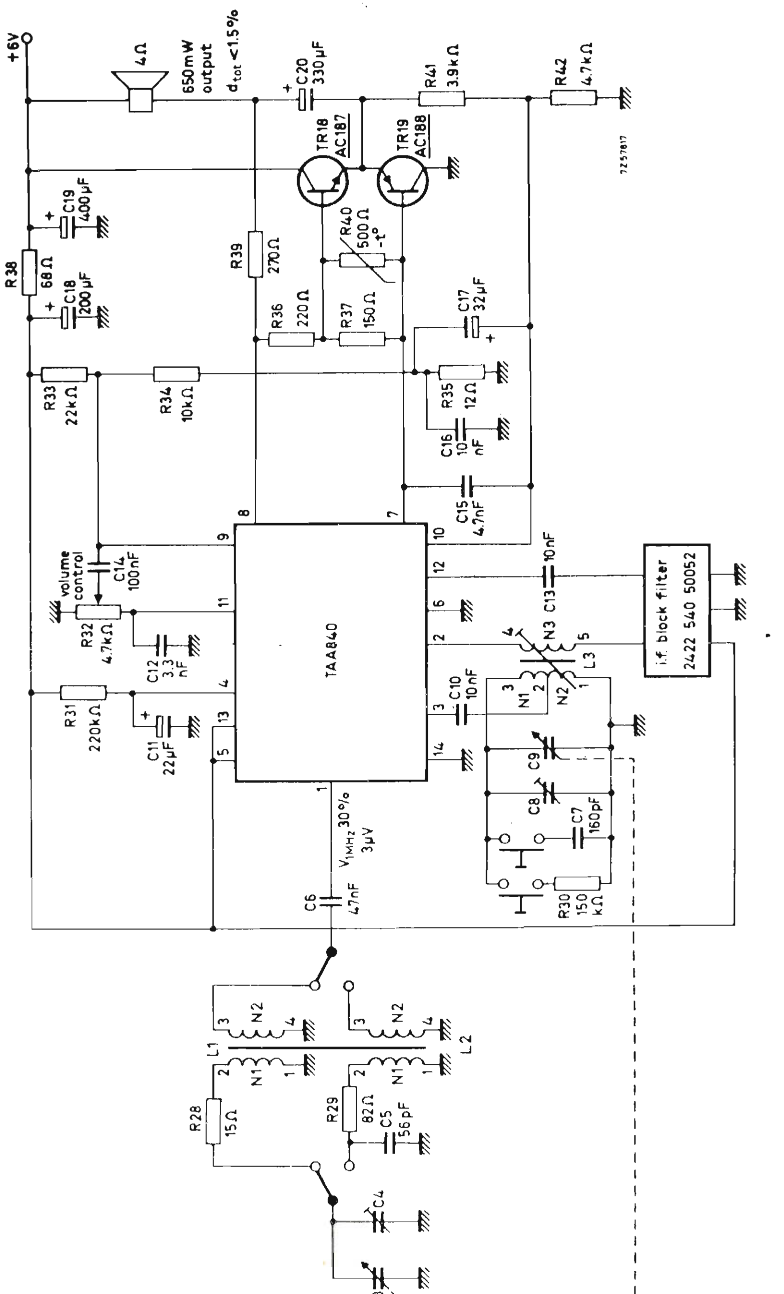

+6V
4Ω
650mW
output
d_{tot} <1.5%
C20
330µF
R41
3.9kΩ
R42
4.7kΩ
TR18
AC187
TR19
AC188
7Z57817
C19
400µF
R38
68Ω
C18
200µF
R39
270Ω
R40
500Ω
-t°
R36
220Ω
R37
150Ω
C17
32µF
R33
22kΩ
R34
10kΩ
R35
12Ω
C16
10
nF
C15
4.7nF
volume
control
C14
100nF
C13
10nF
R32
4.7kΩ
C12
3.3
nF
TAA840
i.f. block filter
2422 540 50052
N3
L3
N1
N2
C10
10nF
R31
220kΩ
C11
22µF
C9
C8
C7
160pF
V_{1MHz} 30%
3µV
C6
47nF
R30
150
kΩ
L1
L2
R28
15Ω
R29
82Ω
C5
56pF
C4
C3

Fig.6.

SURVEY OF THIRD ORDER HYBRID FILTERS

midband frequency f_m (kHz) ± 1 kHz	bandwidth (kHz) at an attenuation of 3 dB	bandwidth (kHz) at an attenuation of 60 dB	at $f_m \pm 9$ kHz S_9 (dB)	attenuation in the stopband up to 5 MHz S_s (dB)	attenuation in the stopband between 5 and 30 MHz S_s (dB)	impedance levels output preceding stage R_s (kΩ)	impedance levels input succeeding stage R_ℓ (kΩ)	transfer-impedance at f_m $\lvert Z_T \rvert$ (kΩ)	trans-ducer loss (dB)	insertion loss (dB)	catalogue number 2422 540
452											50001
455											50002
460	> 4	60	33	> 90	> 70	680	680	63	14.5	14.5	50003
468											50004
470											50005
452											50031
455											50032
460	> 4	60	35	> 90	> 30	200	1.2	0.6	22	6	50033
468											50034
470											50035
452											50051
455											50052
460	> 4	-	33	> 90	> 70	200	1.2	0.6	22	6	50053
468											50054
470											50055

Elenco delle documentazioni tecniche riguardanti i COMPONENTI PASSIVI.

22	- Elementi logici in apparecchiature digitali
35	- Ferroxcube crosscores X 22 - X 30 - X 35
64	- Nuclei ad olla della serie S e D
67	- Introduzione allo studio e all'impiego delle memorie magnetiche
122	- Design with circuit blocks
136	- VDR - Resistori variabili con la tensione
138	- LDR - Resistori variabili con la luce
151	- La logica negli automatismi industriali
167	- Circuiti d'applicazione dei circuit-blocks serie 1
177	- Circuit blocks serie 10
180	- Circuit blocks serie 1
194	- Nuclei in ferroxcube ad olla serie P-P 18/11
196	- Nuclei in ferroxcube ad olla serie P-P 26/16
197	- Nuclei in ferroxcube ad olla serie P-P36/22
198	- Nuclei in feroxcube ad olla serie P-P 42/29
209	- Circuit blocks serie 100
212	- Nuclei in ferroxcube ad olla serie P-P 30/19
238	- Circuiti d'applicazione dei circuit-blocks serie 10
240	- Cristalli di quarzo e filtri
250	- PTC - Resistori a coefficiente di temperatura positivo
262	- Piexoxide
265	- Relé statici Norbits 2 (serie 60). Generalità e applicazioni
271	- Memorie magnetiche complete
282	- Circolari e isolatori a ferrite
283	- Matrici, platrici e stacks
284	- Linee di ritardo e loro applicazioni
289	- Nuclei in ferroxcube per memorie magnetiche
292	- Commutatori Rotativi
293	- Ferriti per radio TV e bassa frequenza
M 1a	- Unità di conteggio serie 50 (ex N. 237)
M 2a	- Elementi d'ingresso e di uscita (ex N. 243)
M 4a	- Connettori per circuiti stampati (ex N. 231)
M 5a	- Circuit blocks serie 40
M 7a	- Testine magnetiche in ferrite (ex N. 175)
M 8a	- Relé statici Norbits 2 serie 60 (ex N. 216)

CP 1b - Altoparlanti e casse acustiche
CP 2b - Risonatori ceramici piezoelettrici
CP 3a - Trasformatori variabili (ex N. 211)
CP 4a - Condensatori fissi: policarbonato, poliestere, carta, mica, polistirene (ex N. 230)
CP 5a - NTC - Resistori a coefficiente di temperatura negativo (ex N. 241)
CP 6a - Resistori fissi: a strato di carbone, a strato metallico, a filo (ex N. 251)
CP 7a - Nuclei in ferroxcube ad H (ex N. 192)
CP 8a - Nuclei in ferroxcube ad olla serie P-P 22/13 (ex N. 195)
CP 9a - Nuclei in ferroxcube ad olla serie P-P 14/8 (ex N. 193)
CP 10a - Nuclei in ferroxcube ad olla serie P-P 11/7
CP 11a - Magneti permanenti (ex N. 199)
CP 12a - Nuclei in ferroxcube R 6 e SM 6
CP 13a - Condensatori ceramici (ex N. 183)
CP 14a - Termoferriti, generalità e applicazioni (ex N. 189)
CP 15a - Resistori variabili. Potenziometri a filo e a carbone - Trimmer potenziometrici miniatura (ex N. 249)
CP 16a - Condensatori elettrolitici (ex N. 248)
CP 17a - Condensatori variabili e trimmer (ex N. 247)
CP 18a - Chassis e circuiti stampati standard (ex N. 206)
CP 19a - Componenti elettromeccanici (ex N. 239)
CP 20a - Nuclei in ferroxcube per trasformatori e chockes (ex N. 30)

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